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(54) Title: A PROCESS FOR PREPARING (BRANCHED-ALKYL) ARYLSULPHONATES AND A (BRANCHED-ALKYL) ARYLSULPHONATE COMPOSITION

**(57) Abstract:** A process for preparing branched alkyl aromatic hydrocarbons, which process comprises contacting branched olefins within an aromatic hydrocarbon under alkylating conditions, which branched olefins have been obtained by a process which comprises dehydrogenating an isoparaffinic composition comprising 0.5 % or less quaternary aliphatic carbon atoms over a suitable catalyst, which isoparaffinic composition has been obtained by hydrocracking and hydroisomerisation of a paraffinic wax and which isoparaffinic composition comprises paraffins having a carbon number in the range of from 7 to 35, of which paraffins at least a portion of the molecules is branched, the average number of branches per paraffin molecules being 0.5 to 2.5 and the branching comprising methyl and optionally ethyl branches, said branched olefins comprising 0.5 % or less quaternary aliphatic hydrocarbons; a process for preparing (branched-alkyl arylsulphonates, comprising sulphonating branched alkyl aromatic hydrocarbons which branched alkyl aromatic hydrocarbons have been prepared by the said process for preparing branched alkyl aromatic hydrocarbons; and branched alkyl aromatic hydrocarbon compositions and (branched-alkyl) arylsulphonate compositions which are obtainable by the processes so defined.

A PROCESS FOR PREPARING (BRANCHED-ALKYL)ARYLSULPHONATES  
AND A (BRANCHED-ALKYL)ARYLSULPHONATE COMPOSITION

FIELD OF THE INVENTION

This invention relates to a process for preparing (branched-alkyl)arylsulphonates and to compositions of the (branched-alkyl)arylsulphonates per se. This 5 invention also relates to a process for preparing intermediate branched alkyl aromatic hydrocarbons and to compositions of the branched alkyl aromatic hydrocarbons per se.

BACKGROUND OF THE INVENTION

10 WO-A-99/05244, WO-A-99/05082 and US-A-6111158 relate to alkylarylsulphonate surfactants of which the alkyl groups are branched. Sources of the alkyl groups are for example paraffins with limited branching obtained by delinearisation of linear paraffins.

15 US-A-5849960 relates to surfactant sulphates based on branched alcohols. The branched alcohols in question have an average number of branches per molecule chain of at least 0.5. The branching comprises not only methyl branching but also ethyl branches, whilst the occurrence 20 of longer branching is not excluded. The branched alcohols are made from branched olefins, which are made by skeletally isomerising linear olefins.

The market always asks for improvements in the performance of existing detergent formulations, inter 25 alia by improving the surfactants present in the detergent formulations. For example, the laundry market asks for improvements in the surfactants' biodegradability, their cold water solubility and their cold water detergency. At least an improvement is sought

in the balance of the properties. By the terminology "an improvement in the balance of the properties" it is meant that at least one property is improved, whilst at least one of the other properties is not deteriorated.

5       The present invention seeks to provide improvements in the performance of the known alkylarylsulphonate surfactants, or at least in an improvement in the balance of their performance properties. Relevant performance properties are biodegradability, cold water solubility  
10      and cold water detergency, for example cold water detergency in water of low hardness and in water of high hardness. Other relevant performance properties are the compatibility of the alkylarylsulphonate surfactants with other components present in detergent formulations, as  
15      described hereinafter, in particular, the compatibility with enzymes, i.e. the inability of the alkylarylsulphonate surfactants to denature enzymes during storage in an aqueous medium. Again other relevant performance properties, in particular for  
20      personal care applications, are mildness to the skin and to the eyes and the ability of high foaming, preferably providing foam with a fine structure of the foam cells. Further, an improved performance is sought as a chemical for enhanced oil recovery applications and for the  
25      removal of oil spillage, viz. an improved ability to emulsify oil/water and oil/brine systems and to stabilise emulsions of oil and water or brine, in particular at high temperature. Independently, the present invention seeks to provide a method for the manufacture of  
30      alkylarylsulphonate surfactants which is more versatile and economically more attractive than the known methods.

SUMMARY OF THE INVENTION

In accordance with this invention alkylarylsulphonate surfactants are prepared by dehydrogenating selected branched paraffins to produce branched olefins.

5      These branched olefins can be converted into branched alkyl aromatics and subsequently into alkylarylsulphonate surfactants. It is an advantage of this invention that surfactants and intermediates can be made with a very low content of molecules which have a linear carbon chain.

10     It is another advantage of the invention that products can be made of which the molecules have a low content of branches having three or more carbon atoms. It is also an advantage of the invention that products can be made of which the molecules have a low content of quaternary

15     aliphatic carbon atoms. Without wishing to be bound by theory, it is believed that the presence of quaternary aliphatic carbon atoms in the molecules of the (branched-alkyl)arylsulphonate surfactants prevents to some extent their biodegradation and the presence of quaternary aliphatic carbon atoms in the isoparaffinic composition is therefore preferably avoided. In fact, it has been determined that the presence of 0.5% or less quaternary aliphatic carbon atoms in the molecules of the

20     surfactants renders the surfactants substantially more biodegradable.

Accordingly, the present invention provides a process for preparing branched olefins, which process comprises dehydrogenating an isoparaffinic composition comprising 0.5% or less quaternary aliphatic carbon atoms over a suitable catalyst which isoparaffinic composition has been obtained by hydrocracking and hydroisomerisation of a paraffinic wax and which isoparaffinic composition comprises paraffins having a carbon number in the range

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of from 7 to 18, of which paraffins at least a portion of the molecules is branched, the average number of branches per paraffin molecule being 0.5 to 2.5 and the branching comprising methyl and optionally ethyl branches, said  
5 branched olefins comprising 0.5% or less quaternary aliphatic hydrocarbons.

The present invention also provides a process for preparing branched alkyl aromatic hydrocarbons, which process comprises contacting branched olefins with an  
10 aromatic hydrocarbon under alkylating conditions, which branched olefins have been obtained by a process which comprises dehydrogenating an isoparaffinic composition over a suitable catalyst, which isoparaffinic composition comprises paraffins having a carbon number in the range  
15 of from 7 to 35, of which paraffins at least a portion of the molecules is branched, the average number of branches per paraffin molecule being at least 0.5 and the branching comprising methyl and optionally ethyl  
branches. In particular, the present invention provides  
20 a process for preparing branched alkyl aromatic hydrocarbons, which process comprises contacting branched olefins with an aromatic hydrocarbon under alkylating conditions, which branched olefins have been obtained by a process which comprises dehydrogenating an  
25 isoparaffinic composition comprising 0.5% or less quaternary aliphatic carbon atoms over a suitable catalyst, which isoparaffinic composition has been obtained by hydrocracking and hydroisomerisation of a paraffinic wax and which isoparaffinic composition  
30 comprises paraffins having a carbon number in the range of from 7 to 35, of which paraffins at least a portion of the molecules is branched, the average number of branches per paraffin molecule being 0.5 to 2.5 and the branching

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comprising methyl and optionally ethyl branches, said branched olefins comprising 0.5% or less quaternary aliphatic hydrocarbons.

The invention also provides a process for preparing 5 (branched-alkyl)arylsulphonates, comprising sulphonating branched alkyl aromatic hydrocarbons which branched alkyl aromatic hydrocarbons have been prepared by the process for preparing branched alkyl aromatic hydrocarbons in accordance with the present invention.

10 Further, the invention provides a branched olefin composition, which is obtainable in accordance with the present invention.

15 Further, the invention provides a branched alkyl aromatic hydrocarbon composition which is obtainable in accordance with the present invention.

In a further aspect the present invention provides a 20 (branched-alkyl)arylsulphonate composition which is obtainable in accordance with the present invention.

Without wishing to be bound by theory, it is believed that any improvement in the performance 25 properties of the (branched-alkyl)arylsulphonates prepared in accordance with this invention, compared with the known (branched-alkyl)arylsulphonates, resides in a difference in the distribution of branching along the respective paraffinic chains. Such differences in the distribution of branching are truly unexpected in view of the prior art and, therefore, they are inventive.

#### DETAILED DESCRIPTION OF THE INVENTION

As described herein, the isoparaffinic composition 30 and the compositions of branched olefins, branched alkyl aromatic compounds and (branched-alkyl)arylsulphonates derived therefrom are generally mixtures comprising molecules with different, consecutive carbon numbers.

Typically at least 75 %w, more typically at least 90 %w, of these compositions represent a range of molecules of which the heaviest molecules comprises at most 6 carbon atoms more than the lightest molecules.

5       The isoparaffinic composition comprises paraffins having a carbon number in the range of from 7 to 35, of which paraffins at least a portion of the molecules is branched. Preferably, the isoparaffinic composition comprises paraffins having a carbon number in the range  
10      of from 7 to 18, more preferably from 10 to 18. Preferably at least 75%w, more preferably at least 90%w, of the isoparaffinic composition consists of paraffins having a carbon number in the range of from 10 to 18. In practice, frequently at most 99.99%w, more frequently at  
15      most 99.9%w, of the isoparaffinic composition consists of paraffins having a carbon number in the range of from 10 to 18. It is most preferred that the isoparaffinic composition comprises paraffins having a carbon number in the range of from 11 to 14, in which case preferably at  
20      least 75%w, more preferably at least 90%w, of the isoparaffinic composition consists of paraffins having a carbon number in the range of from 11 to 14. In practice, frequently at most 99.99%w, more frequently at most 99.9%w, of the isoparaffinic composition consists of  
25      paraffins having a carbon number in the range of from 11 to 14. These selections are based on the effects that the paraffins of a lower carbon number ultimately yield surfactants, which are more volatile, and that the paraffins of a higher carbon number ultimately yield  
30      surfactants with less water solubility.

The average number of branches per paraffin molecule present in the isoparaffinic composition is at least 0.5, calculated over the total of the branched paraffins and,

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if present, the linear paraffins. Suitably the average number of branches is at least 0.7, and more suitably at least 0.8, for example 1.0. Suitably the average number of branches is at most 2.0, preferably at most 1.8, and 5 in particular at most 1.4.

The number of methyl branches present in the isoparaffinic composition is suitably at least 20%, more suitably at least 40%, preferably at least 50% of the total number of branches. In practice the number of 10 methyl branches is frequently at most 99%, more frequently at most 98% of the total number of branches. If present, the number of ethyl branches is suitably at least 0.1%, in particular at least 1%, more in particular at least 2% of the total number of branches. Suitably, 15 the number of ethyl branches is at most 20%, in particular at most 15%, more in particular at most 10% of the total number of branches. The number of any branches, if present, other than methyl and ethyl branches, may be less than 10%, in particular less than 20 5% of the total number of branches. The number of any branches, if present, other than methyl and ethyl branches, may be more than 0.1%, typically more than 1% of the total number of branches.

The number of quaternary aliphatic carbon atoms 25 present in the isoparaffinic composition is preferably low. For applications where biodegradability is not as critical, the number of quaternary aliphatic carbon atoms is suitably less than 2% of the carbon atoms present, more suitably less than 1%. For any application, and 30 particularly for applications where biodegradability is important, the number of quaternary aliphatic carbon atoms preferably is 0.5 % or less, most preferably less than 0.5 %, and in particular less than 0.3%. In

practice the number of quaternary aliphatic carbon atoms present in the isoparaffinic composition is frequently more than 0.01% of the aliphatic carbon atoms present, more frequently more than 0.02%.

5       The content of branched paraffins of the isoparaffinic composition is typically at least 50%w, more typically at least 70%w, most typically at least 90%w, preferably at least 95%w, more preferably at least 99%w, in particular at least 99.9%w, relative to the  
10      weight of the isoparaffinic composition. In practice the content of branched paraffins is frequently at most 99.99 %w, more frequently at most 99.95%w, relative to the weight of the isoparaffinic composition. The content of linear paraffins of the isoparaffinic composition is  
15      typically at most 50%w, more typically at most 30%w, most typically at most 10%w, preferably at most 5%w, more preferably at most 1%w, in particular at most 0.1%w, relative to the weight of the isoparaffinic composition.  
In practice the content of linear paraffins is frequently  
20      at least 0.01%w, more frequently at least 0.02%w, relative to the weight of the isoparaffinic composition.

The isoparaffinic composition may originate from various sources. For example, suitable isoparaffinic compositions may be selected from crude oil distillation fractions. Such crude oil distillation fractions may be treated to partially or, more preferably, completely remove sulphur and/or nitrogen containing components.

Alternatively, the isoparaffinic composition may be obtained by hydroisomerisation of a paraffinic composition, i.e. a composition which comprises predominantly linear paraffins, such as obtainable from a Fischer Tropsch process or from an ethylene oligomerisation process (after hydrogenation). Linear

paraffins obtained in a Fischer Tropsch synthesis are particularly preferred because Fischer Tropsch products are generally very low in their content of sulphur and nitrogen and they are cost effective. The Fischer  
5 Tropsch products may or may not comprise oxygenates. The product obtained in the hydroisomerisation process may be fractionated, for example, by distillation or otherwise, in order to isolate an isoparaffinic product of the desired composition. Such a hydroisomerisation process  
10 and subsequent fractionation is known, for example from US-A-5866748.

Preferably, the isoparaffinic composition is obtained by hydrocracking and hydroisomerisation of a paraffinic wax, in particular a slack wax, a wax obtained  
15 in a Fischer Tropsch synthesis or a polyethylene wax. The paraffinic wax comprises typically linear paraffins having at least 5 carbon atoms, preferably at least 15 carbon atoms, more preferably at least 25 carbon atoms. In practice, the paraffinic wax comprises frequently  
20 linear paraffins of which the number of carbon atoms may be high, for example up to 100 or up to 200 and even more. Paraffinic wax obtained in a Fischer Tropsch synthesis is particularly preferred because these are generally very low in their content of sulphur and  
25 nitrogen and they are cost effective. The product obtained in the hydrocracking/hydroisomerisation process may be fractionated, for example, by distillation or otherwise, in order to isolate an isoparaffinic product of the desired composition. Such a  
30 hydrocracking/hydroisomerisation process and subsequent fractionation is known, for example from US-A-5833839. Generally, the hydrocracking/hydroisomerisation process

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involves hydrocracking with simultaneous hydroisomerisation.

The isoparaffinic composition may be treated to lower the content of linear paraffins, in order to favourably adjust the average number of branches in the isoparaffinic composition. Such separation may be accomplished by separation using a molecular sieve as absorbent. The molecular sieve may be, for example, a zeolite 4A, a zeolite 5A, a zeolite X or a zeolite Y. Reference may be made to "Kirk-Othmer Encyclopedia of Chemical Technology", 4<sup>th</sup> edition, Volume 1, pp. 589-590, and Volume 16, pp. 911-916; and "Handbook of Petroleum Refining Processes" (R A Meyers, Ed.), 2<sup>nd</sup> edition, pp. 10.45-10.51, 10.75-10.77.

Catalysts suitable for the dehydrogenation of the isoparaffinic composition may be selected from a wide range. For example, they may be based on a metal or metal compound deposited on a porous support, the metal or metal compound being one or more selected for example from chrome oxide, iron oxide and, preferably, the noble metals. The noble metals are understood to be the metals of the group formed by platinum, palladium, iridium, ruthenium, osmium and rhodium. Preferred noble metals are palladium and, in particular, platinum.

Suitable porous supports may be supports of a carbon nature such as activated carbon, coke and charcoal; silica or silica gel, or other natural or synthetic clays or silicates, for example hydrotalcites; ceramics; refractory inorganic oxides such as alumina, titania or magnesia; naturally or synthetic crystalline aluminosilicates such as mordenite or faujasite; and combinations of two or more elements selected from these

groups. The porous support is preferably an alumina, in particular gamma alumina or eta alumina.

The quantity of the metal or metal compound deposited on the porous support is not material to this invention. The quantity may suitably be selected in the range of from 0.01 to 5%w, preferably from 0.02 to 2%w, based on the weight of the catalyst.

Further metals may be present in the catalyst used for the dehydrogenation of the isoparaffinic composition, in particular in the catalysts which comprise a noble metal. Such further metals may suitably be selected from Group 3a, Group 4a and Group 5a of the Periodic Table of Elements (cf. R C Weast (Ed.) "Handbook of Chemistry and Physics", 54<sup>th</sup> edition, CRC Press, inside cover). In particular, indium may be selected from Group 3a, tin may be selected from Group 4a or bismuth may be selected from Group 5a. Especially suitable further metals are alkali and alkaline earth metals. Preferred alkali metals are potassium, and in particular lithium.

Further elements which may be present in the catalyst used for the dehydrogenation of the isoparaffinic composition are halogens, in particular in combination with a metal of Group 4a, more in particular in combination with tin. Chlorine is a preferred halogen.

The quantity of such further metals or halogens may independently be in the range of from 0.01 to 5%w, preferably from 0.02 to 2%w, based on the weight of the catalyst.

Suitable catalysts for the dehydrogenation of the isoparaffinic composition are, for example, chrome oxide on gamma alumina, platinum on gamma alumina, palladium on gamma alumina, platinum/lithium on gamma alumina,

platinum/potassium on gamma alumina, platinum/tin on gamma alumina, platinum/tin on hydrotalcite, platinum/indium on gamma alumina and platinum/bismuth on gamma alumina.

5       The dehydrogenation may be operated at a wide range of conditions. Suitably the temperature is in the range of from 300°C to 700 °C, more suitably in the range of from 400°C to 600 °C, in particular in the range of from 450°C to 550 °C. The total pressure may be an elevated pressure, such as in the range of from 110 to 1500 kPa a  
10      (1.1 to 15 bara) (i.e. kPa or bar absolute), preferably in the range of from 130 to 1000 kPa a (1.3 to 10 bara), in particular in the range of from 150 to 500 kPa a (1.5 to 5 bara). In order to prevent coking, hydrogen may be  
15      fed together with the isoparaffinic composition.  
Suitably, hydrogen and paraffins present in the isoparaffinic composition are fed at a molar ratio in the range of from 0.1 to 20, more suitably this molar ratio is in the range of from 0.5 to 15, in particular this  
20      molar ratio is in the range of from 1 to 10.

25      The residence time in the dehydrogenation is typically selected such that conversion level of the isoparaffinic composition is kept below 50 mole%, preferably in the range of from 5 to 30 mole%, in particular in the range of from 10 to 20 mole%. By keeping the conversion level low, side reactions may to some extent be prevented, such as diene formation and cyclisation reactions. Non-converted paraffins and dehydrogenated compounds may be separated from the  
30      dehydrogenation product and, if desired, non-converted paraffins may be recycled to the dehydrogenation step. Such separation may be accomplished by extraction, by

extractive distillation or, preferably, by using a molecular sieve as absorbent. The molecular sieve may be, for example, a zeolite 4A, a zeolite 5A, a zeolite X or a zeolite Y. If desired, linear olefins may be separated at least to some extent from branched olefin so that the content of branched olefin in the product as obtained from the dehydrogenation is increased further, but this option is generally not preferred.

The skilled person is aware of the techniques of preparing the catalysts, performing the dehydrogenation step and performing associated separation steps, for use in this invention. For example, suitable procedures for preparing catalysts and performing the dehydrogenation are known from US-A-5012021, US-A-3274287, US-A-3315007, US-A-3315008, US-A-3745112, US-A-4430517. For techniques suitable for the separation of branched olefins from linear olefins, reference may be made to "Kirk-Othmer Encyclopedia of Chemical Technology", 4<sup>th</sup> edition, Volume 1, pp. 589-591, and Volume 16, pp. 911-916; and "Handbook of Petroleum Refining Processes" (R A Meyers, Ed.), 2<sup>nd</sup> edition, pp. 10.45-10.51, 10.79-10.81.

The dehydrogenation in accordance with this invention yields typically a branched olefin composition comprising olefins having a carbon number in the range of from 7 to 35, of which olefins at least a portion of the molecules is branched, the average number of branches per molecule being at least 0.5 and the branching comprising methyl and optionally ethyl branches. Preferably, the branched olefin composition comprises olefins having a carbon number in the range of from 7 to 18, more preferably from 10 to 18. Preferably at least 75%w, more preferably at least 90%w, of the branched olefin composition consists of olefins having a carbon number in

the range of from 10 to 18. In practice, frequently at most 99.99%w, more frequently at most 99.9%w, of the branched olefin composition consists of olefins having a carbon number in the range of from 10 to 18. It is most 5 preferred that the branched olefin composition comprises olefins having a carbon number in the range of from 11 to 14, in which case preferably at least 75%w, more preferably at least 90%w, of the branched olefin composition consists of olefins having a carbon number in 10 the range of from 11 to 14. In practice, frequently at most 99.99%w, more frequently at most 99.9%w, of the branched olefin composition consists of olefins having a carbon number in the range of from 11 to 14.

Suitably the average number of branches per olefin 15 molecule present in the branched olefin composition is at least 0.7, and more suitably at least 0.8, for example 1.0. Suitably the average number of branches is at most 2.0, preferably at most 1.8, and in particular at most 1.4. The number of methyl branches is suitably at least 20 20%, more suitably at least 40%, preferably at least 50% of the total number of branches. In practice the number of methyl branches is frequently at most 99%, more frequently at most 98% of the total number of branches. If present, the number of ethyl branches is suitably at 25 least 0.1%, in particular at least 1%, more in particular at least 2% of the total number of branches. Suitably, the number of ethyl branches is at most 20%, in particular at most 15%, more in particular at most 10% of the total number of branches. The number of any branches, if present, other than methyl and ethyl 30 branches, may be less than 10%, in particular less than 5% of the total number of branches. The number of any branches, if present, other than methyl and ethyl

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branches, may be more than 0.1%, typically more than 1% of the total number of branches.

The number of quaternary aliphatic carbon atoms present in the branched olefins is preferably low. For 5 applications where biodegradability is not as critical, the number of quaternary aliphatic carbon atoms is suitably less than 2% of the carbon atoms present, more suitably less than 1%. For any application, and particularly for applications where biodegradability is 10 important, the number of quaternary aliphatic carbon atoms preferably is 0.5 % or less, most preferably less than 0.5 %, and in particular less than 0.3%. In practice the number of quaternary aliphatic carbon atoms present in the branched olefins is frequently more than 15 0.01% of the aliphatic carbon atoms present, more frequently more than 0.02%.: :

The content of branched olefins of the branched olefin composition is typically at least 50%w, more typically at least 70%w, most typically at least 90%w, 20 preferably at least 95%w, more preferably at least 99%w, in particular at least 99.9%w, relative to the weight of the branched olefin composition. In practice the content of branched olefins is frequently at most 99.99 %w, more frequently at most 99.95%w, relative to the weight of the 25 branched olefin composition. The content of linear olefins of the branched olefin composition is typically at most 50%w, more typically at most 30%w, most typically at most 10%w, preferably at most 5%w, more preferably at most 1%w, in particular at most 0.1%w, relative to the weight of the branched olefin composition. In practice 30 the content of linear olefins is frequently at least 0.01%w, more frequently at least 0.05%w, relative to the weight of the branched olefins composition.

The branched olefin composition may comprise paraffins, which were not converted in the dehydrogenation. Such non-converted paraffins may suitably be removed in a subsequent stage; in particular during the work-up of the alkylation reaction mixture, as described hereinafter, and recycled to the dehydrogenation step. If the branched olefin composition comprises paraffins, the specifications given in the three paragraphs preceding the present paragraph relate to the olefinic portion of the branched olefin composition. Typically quantity of the olefinic portion present in the branched olefin composition is in the range of from 1 to 50% mole relative to the total number of moles of olefins and paraffins present, more typically in the range of from 5 to 30% mole, in particular from 10 to 20% mole, on the same basis. Typically quantity of the paraffinic portion present in the branched olefin composition is in the range of from 50 to 99% mole relative to the total number of moles of olefins and paraffins present, more typically in the range of from 70 to 95% mole, in particular from 80 to 90% mole, on the same basis.

The preparation of branched alkyl aromatic hydrocarbons by contacting the branched olefins with the aromatic hydrocarbon may be performed under a large variety of alkylating conditions. Preferably, the said alkylation leads to monoalkylation, and only to a lesser degree to dialkylation or higher alkylation, if any.

The aromatic hydrocarbon applicable in the alkylation may be one or more of benzene; toluene; xylene, for example o-xylene or a mixture of xylenes; and naphthalene. Preferably, the aromatic hydrocarbon is benzene.

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The molar ratio of the branched olefins to the aromatic hydrocarbons may be selected from a wide range. In order to favor monoalkylation, this molar ratio is suitably at least 0.5, preferably at least 1, in particular at least 1.5. In practice this molar ratio is frequently less than 1000, more frequently less than 100.

10 The said alkylation may or may not be carried out in the presence of a liquid diluent. Suitable diluents are, for example, paraffin mixtures of a suitable boiling range, such as the paraffins which were not converted in the dehydrogenation and which were not removed from the dehydrogenation product. An excess of the aromatic hydrocarbon may act as a diluent.

15 The alkylation catalyst, which may be applied, may be selected for example from a large range of zeolitic alkylation catalysts. In order to favour monoalkylation, it is preferred that the zeolitic alkylation catalysts have pore size dimensions in the range of from 4 to 9 Å, more preferably from 5 to 8 Å and most preferably from 20 5.5 to 7 Å, on the understanding that when the pores have an elliptical shape, the larger pore size dimension is the dimension to be considered. The pore size dimensions of zeolites has been specified in W M Meier and D H Olson, "Atlas of Zeolite Structure Types", 2<sup>nd</sup> revised edition (1987), published by the Structure Commission of the International Zeolite Association. Suitable zeolitic alkylation catalysts are zeolites in acidic form selected from zeolite Y and zeolites ZSM-5 and ZSM-11.

25 Preferably the zeolitic alkylation catalysts are zeolites in acidic form selected from mordenite, ZSM-4, ZSM-12, ZSM-20, offretite, gemelinite and cancrinite.

30 Particularly preferred zeolitic alkylation catalysts are

the zeolites which have an NES zeolite structure type, including isotypic framework structures such as NU-87 and gottardiite, as disclosed in US-A-6111158. The zeolites which have an NES zeolite structure type give,  
5 advantageously, a high selectivity to 2-aryl-alkanes. Further examples of suitable zeolitic alkylation catalyst have been given in WO-A-99/05082.

Suitably, the zeolitic alkylation catalyst has a molar ratio of Si to Al of at least 5:1 and suitably at  
10 most 500:1, in particular at most 100:1. In particular when the zeolitic alkylation catalyst is of the NES zeolite structure type, the molar ratio of Si to Al is preferably in the range of from 5:1 to 25:1, more preferably from 10:1 to 20:1. The molar ratio of Si to  
15 Al of the zeolitic alkylation catalyst is meant to be the molar ratio of the  $\text{SiO}_4$  tetrahedra to the  $\text{AlO}_4$  tetrahedra, i.e. the framework Si/Al molar ratio.

The zeolitic alkylation catalyst has preferably at least a portion of the cationic sites occupied by ions  
20 other than alkali or alkaline earth metal ions. Such replacing ions could be one or more selected from the group of for example ammonium, hydrogen and rare earth. In a preferred embodiment the zeolitic alkylation catalyst is at least partly in the hydrogen form, i.e.  
25 acidic form, in particular completely in the hydrogen form. Suitably at least 10%, preferably at least 50%, more preferably at least 90% of the cationic sites is occupied by hydrogen ions. In practice, frequently at most 99%, more frequently at most 95% of the cationic sites is occupied by hydrogen ions. This is generally accomplished by exchange of the alkali metal ion or another ion for a hydrogen ion precursors, e.g. ammonium ions, which upon calcination yields the hydrogen form.